

1 What is claimed is:

2

3 1. In a data processing network including a client and a file server, a method of
4 access to a storage object in the file server, said method comprising:

5 the client using a block level access protocol over the network to access the
6 storage object; and

7 the file server accessing the storage object by accessing a file containing data of
8 the storage object.

9

10 2. The method as claimed in claim 1, wherein the storage object is a virtual SCSI
11 direct access storage device, and the block level access protocol is SCSI.

12

13 3. The method as claimed in claim 1, wherein the storage object is a logical volume.

14

15 4. The method as claimed in claim 3, wherein the logical volume is raw, sliced,
16 striped, or concatenated.

17

18 5. The method as claimed in claim 1, which includes the file server copying the file
19 concurrent with the client using the block level access protocol over the network to write
20 data to the storage object.

21

22 6. The method as claimed in claim 5, wherein the network is an IP network, the
23 client uses the block level protocol over a first TCP/IP connection over the network to

1 access the storage object, and the client initiates the copying of the file by sending a
2 command over a second TCP/IP connection.

3

4 7. The method as claimed in claim 6, wherein the first TCP/IP connection is
5 concurrent with the second TCP/IP connection.

6

7 8. The method as claimed in claim 6, which includes the client pausing the writing
8 of data to the storage object after a commit operation, and during the pause, the client
9 initiating the copying of the file by sending the command over the second TCP/IP
10 connection.

11

12 9. The method as claimed in claim 1, which includes the file server also providing
13 access to the storage object over the network by means of a file access protocol over the
14 network, the file access protocol accessing the file containing the data of the storage
15 object.

16

17 10. The method as claimed in claim 9, wherein the client uses a UNIX or Linux
18 operating system, and the file access protocol is NFS.

19

20 11. The method as claimed in claim 9, wherein the client uses a Windows operating
21 system, and the file access protocol is CIFS.

22

1 12. The method as claimed in claim 1, wherein the file containing the data of the
2 storage object also contains attributes of the storage object, and the method includes the
3 file server accessing the attributes of the storage object when the client uses the block
4 level access protocol over the network to access the storage object.

5
6 13. The method as claimed in claim 1, wherein the file containing the data of the
7 storage object is in a file system which includes another file containing attributes of the
8 storage object, and the method includes the file server accessing the attributes of the
9 storage object when the client uses a block level access protocol over the network to
10 access the storage object.

11
12 14. In a data processing network including a client and a file server, a method of
13 access to a virtual direct access storage device in the file server, attributes and data of the
14 virtual direct access storage device being stored in at least one file in the file server, said
15 method comprising:

16 the client using a block level access protocol over the network to access the
17 virtual direct access storage device in the file server, the file server responding to
18 commands in accordance with the block level access protocol for access to the virtual
19 direct access storage device by accessing the attributes and data of the virtual direct
20 access storage device; and

21 the file server providing access over the network to the virtual block storage
22 device in accordance with a file access protocol by accessing said at least one file in the
23 file server.

1

2 15. The method as claimed in claim 14, wherein the attributes and data of the virtual
3 direct access storage device are stored together in a single file.

4

5 16. The method as claimed in claim 14, wherein the attributes and data of the virtual
6 direct access storage device are stored in separate files in a common file system.

7

8 17. The method as claimed in claim 14, which includes the file server copying the
9 data of the virtual direct access storage device concurrent with the client using the block
10 level access protocol over the network to write data to the virtual direct access storage
11 device.

12

13 18. The method as claimed in claim 17, wherein the network is an IP network, the
14 client uses the block level protocol over a first TCP/IP connection over the network to
15 access the virtual direct access storage device, and the client initiates the copying of said
16 at least one file by sending a command over a second TCP/IP connection.

17

18 19. The method as claimed in claim 18, wherein the first TCP/IP connection is
19 concurrent with the second TCP/IP connection.

20

21 20. The method as claimed in claim 18, which includes the client pausing the writing
22 of data to the virtual direct access storage device after a commit operation, and during the

1 pause, the client initiating the copying of the data of the virtual direct access storage
2 device by sending the command over the second TCP/IP connection.

3
4 21. The method as claimed in claim 14, wherein the network is an IP network, and the
5 block level access protocol is SCSI.

6
7 22. The method as claimed in claim 14, wherein the client uses a UNIX or Linux
8 operating system, and the file access protocol is NFS.

9
10 23. The method as claimed in claim 14, wherein the client uses a Windows operating
11 system, and the file access protocol is CIFS.

12
13 24. A network file server comprising:
14 data storage;
15 an interface for coupling the data storage to a data network; and
16 at least one processor programmed for permitting clients in the data network to
17 access the data storage in accordance with a plurality of access protocols;
18 the data storage containing at least one file for storing file attributes and for
19 storing metadata defining a virtual direct access storage device and for storing data of the
20 virtual direct access storage device;
21 the access protocols including at least one block level access protocol for access
22 to the virtual direct access storage device by accessing the metadata and data of the
23 virtual direct access storage device; and

1 the access protocols including at least one file access protocol for accessing said
2 at least one file.

3
4 25. The network file server as claimed in claim 24, wherein the metadata includes
5 attributes of the virtual direct access storage device, and the attributes of the virtual direct
6 access storage device and the data of the virtual direct access storage device are stored
7 together in a single file.

8
9 26. The network file server as claimed in claim 24, wherein the metadata includes
10 attributes of the virtual direct access storage device, and the attributes of the virtual direct
11 access storage device and the data of the virtual direct access storage device are stored in
12 separate files in a common file system.

13
14 27. The network file server as claimed in claim 24, wherein the metadata includes
15 attributes of the virtual direct access storage device and the attributes of the virtual direct
16 access storage device specify an internal organization of the virtual direct access storage
17 device.

18
19 28. The network file server as claimed in claim 27, wherein the specified internal
20 organization of the virtual direct access storage device includes a RAID level.

21
22 29. The network file server as claimed in claim 27, wherein the specified internal
23 organization of the virtual direct access storage device includes a striping pattern.

1

2 30. The network file server as claimed in claim 24, which includes a snapshot copy
3 facility for copying the data of the virtual direct access storage device concurrent with a
4 client using the block level access protocol over the network to write data to the virtual
5 direct access storage device.

6

7 31. The network file server as claimed in claim 30, wherein the interface is an IP
8 interface, and the network file server is programmed to permit the client to write data to
9 the virtual direct access storage device using the block level access protocol over a first
10 TCP/IP connection over the network, and the network file server is programmed to
11 initiate copying of the file containing data of the virtual direct access storage device upon
12 receipt of a command from the client over a second TCP/IP connection over the network.

13

14 32. The network file server as claimed in claim 31, wherein the network file server is
15 programmed so that the first TCP/IP connection is concurrent with the second TCP/IP
16 connection.

17

18 33. The network file server as claimed in claim 24, wherein the interface is an IP
19 interface, and wherein the network file server includes an IP replication facility for
20 replicating files from the data storage over the network.

21

22 34. The network file server as claimed in claim 24, wherein the interface is an IP
23 interface, and the block level access protocol is SCSI.

1
2 35. The network file server as claimed in claim 24, wherein the file access protocol is
3 NFS.

4
5 36. The network file server as claimed in claim 24, wherein the file access protocol is
6 CIFS.

7
8 37. A network file server comprising:
9 data storage;
10 an interface for coupling the data storage to an IP data network; and
11 at least one processor programmed for permitting clients in the data network to
12 access the data storage in accordance with a plurality of access protocols;
13 the data storage containing at least one file for storing file attributes and for
14 storing metadata defining a virtual SCSI direct access storage device and for storing data
15 of the virtual direct access storage device;
16 the access protocols including a block level access protocol for client access to the
17 virtual SCSI direct access storage device over the IP network by accessing the metadata
18 and data of the virtual direct access storage device;
19 the access protocols including at least one file access protocol for accessing said
20 at least one file; and
21 the network file server includes a facility for remote replication of said at least
22 one file over the IP network concurrent with client write access to the virtual SCSI direct
23 access device over the IP network using the block level access protocol.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

38. The network file server as claimed in claim 37, wherein the metadata includes attributes of the virtual SCSI direct access storage device, and the attributes of the virtual SCSI direct access storage device and the data of the virtual SCSI direct access storage device are stored together in a single file.

39. The network file server as claimed in claim 37, wherein the metadata includes attributes of the virtual SCSI direct access storage device, and the attributes of the virtual SCSI direct access storage device and the data of the virtual SCSI direct access storage device are stored in separate files in a common file system.

40. The network file server as claimed in claim 37, wherein the metadata includes attributes of the virtual SCSI direct access storage device, and the attributes of the virtual SCSI direct access storage device specify an internal organization of the virtual SCSI direct access storage device.

41. The network file server as claimed in claim 40, wherein the specified internal organization of the virtual SCSI direct access storage device includes a RAID level.

42. The network file server as claimed in claim 40, wherein the specified internal organization of the virtual SCSI direct access storage device includes a striping pattern.

1 43. The network file server as claimed in claim 37, wherein the network file server is
2 programmed to permit a client to write data to the virtual SCSI direct access storage
3 device using the block level access protocol over a first TCP/IP connection over the
4 network, and the network file server is programmed to initiate remote replication of said
5 at least one file upon receipt of a command from the client over a second TCP/IP
6 connection over the network.

7
8 44. The network file server as claimed in claim 43, wherein the network file server is
9 programmed so that the first TCP/IP connection is concurrent with the second TCP/IP
10 connection.

11
12 45. The network file server as claimed in claim 37, wherein said at least one file
13 access protocol includes NFS.

14
15 46. The network file server as claimed in claim 37, wherein said at least one file
16 access protocol includes CIFS.

17
18 47. The network file server as claimed in claim 37, wherein the block-level access
19 protocol includes the SCSI protocol.

20
21 48. The network file server as claimed in claim 37, wherein the bock-level access
22 protocol includes the iSCSI protocol.

23

1 49. The network file server as claimed in claim 37, which includes a snapshot copy
2 facility for creating snapshot copies of said at least one file, and wherein the snapshot
3 copy facility is coupled to the facility for remote replication for transmission of data from
4 the snapshot copies over the IP network concurrent with client write access to the virtual
5 SCSI direct access device over the IP network using the block level access protocol.